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SUBJECT: Two-Stage, Fully Reusable Space Shuttle Lunar Mission Capability Case 710

DATE: October 27, 1969

FROM: W. H. Eilertson

MEMORANDUM FOR FILE

A previous analysis showed that a Stage and One Half (SOH) Space Shuttle could be used in place of a nuclear shuttle to deliver payload to lunar orbit (Reference 1). Recently a decision was made by NASA to drop the SOH and to consider only fully reusable systems. This suggested that fully reusable systems be analyzed to see if they also can serve as a substitute for the nuclear stage.

To determine the lunar orbit payload capability of a typical fully reusable space shuttle, the MSC two stage concept (Figure 1) from Reference 2 was analyzed. Retro-braking as opposed to aero-braking at earth return was assumed. This enables the heat shield, designed for earth orbit return velocities, to remain unchanged. The velocity increments used in this analysis for the lunar mission are as follows:

TLI and retro-braking = 10,404 fps

LOI = 3,063 fps

TEI = 3,159 fps

Analysis showed that the orbiter stage as it stands was not capable of making a round trip to the moon. As a consequence, auxiliary propellant tanks are required. These tanks were assumed to have a mass fraction of .05.

Figure 2 shows the total payload delivered to lunar orbit as a function of the weight of the fully fueled auxiliary tanks. For the lunar payload weight equivalent to the nuclear shuttle (116,00 lbs., Reference 1), the tank plus propellant weight required is approximately 527,000 lbs. The tank dry weight is only 26,360 lbs. This weight is easily within the shuttle vehicle's payload capacity (50,000 lbs.). However, the tank size that is required (22 ft. diameter by about 53 ft. length) cannot fit into the cargo bay in one piece. It can be placed into earth orbit by dividing it into 2 sections and delivering it by two MSC shuttles or in one piece on the Saturn V.

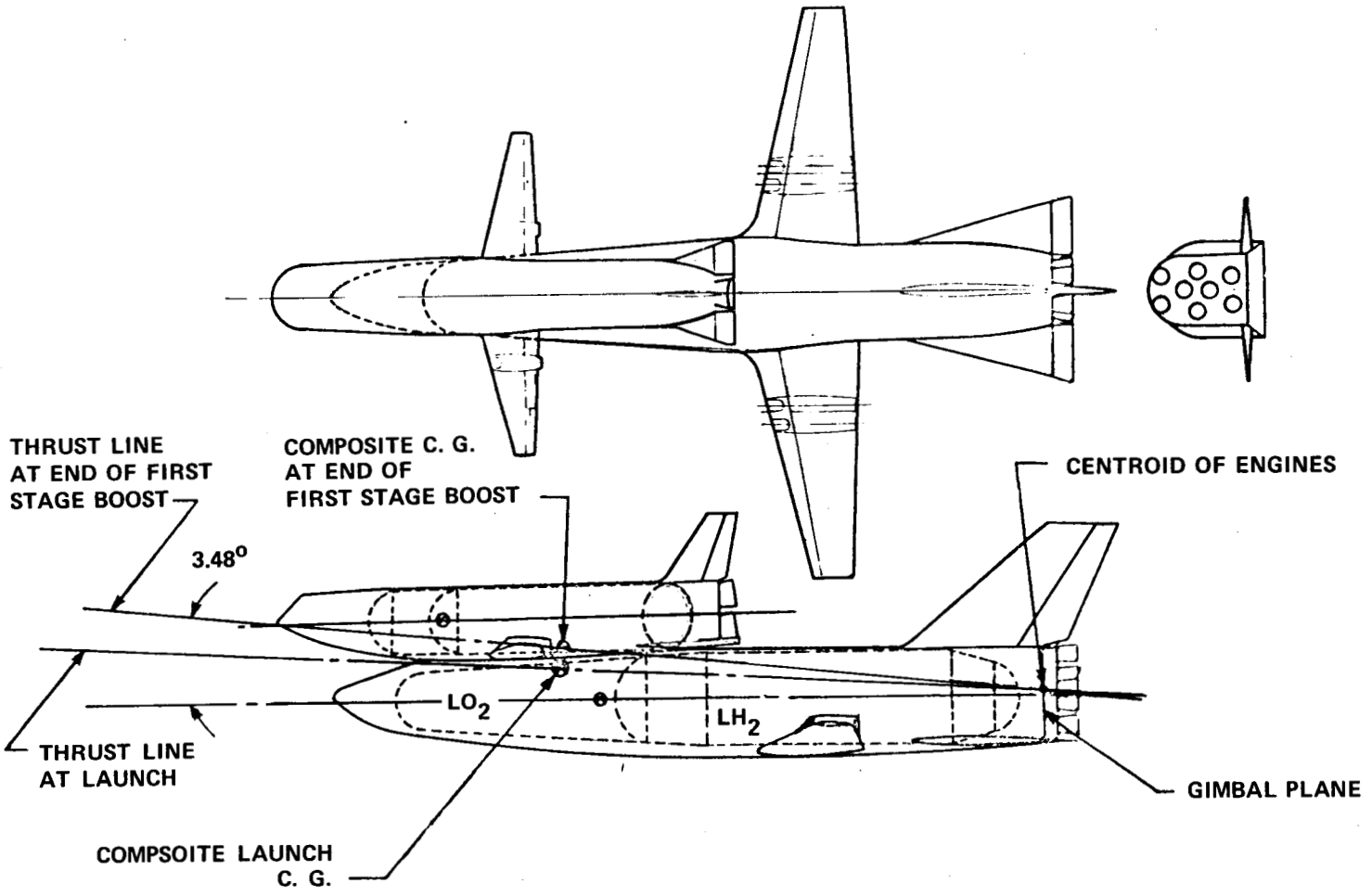

FIGURE 1 - MSC TWO STAGE CONCEPT

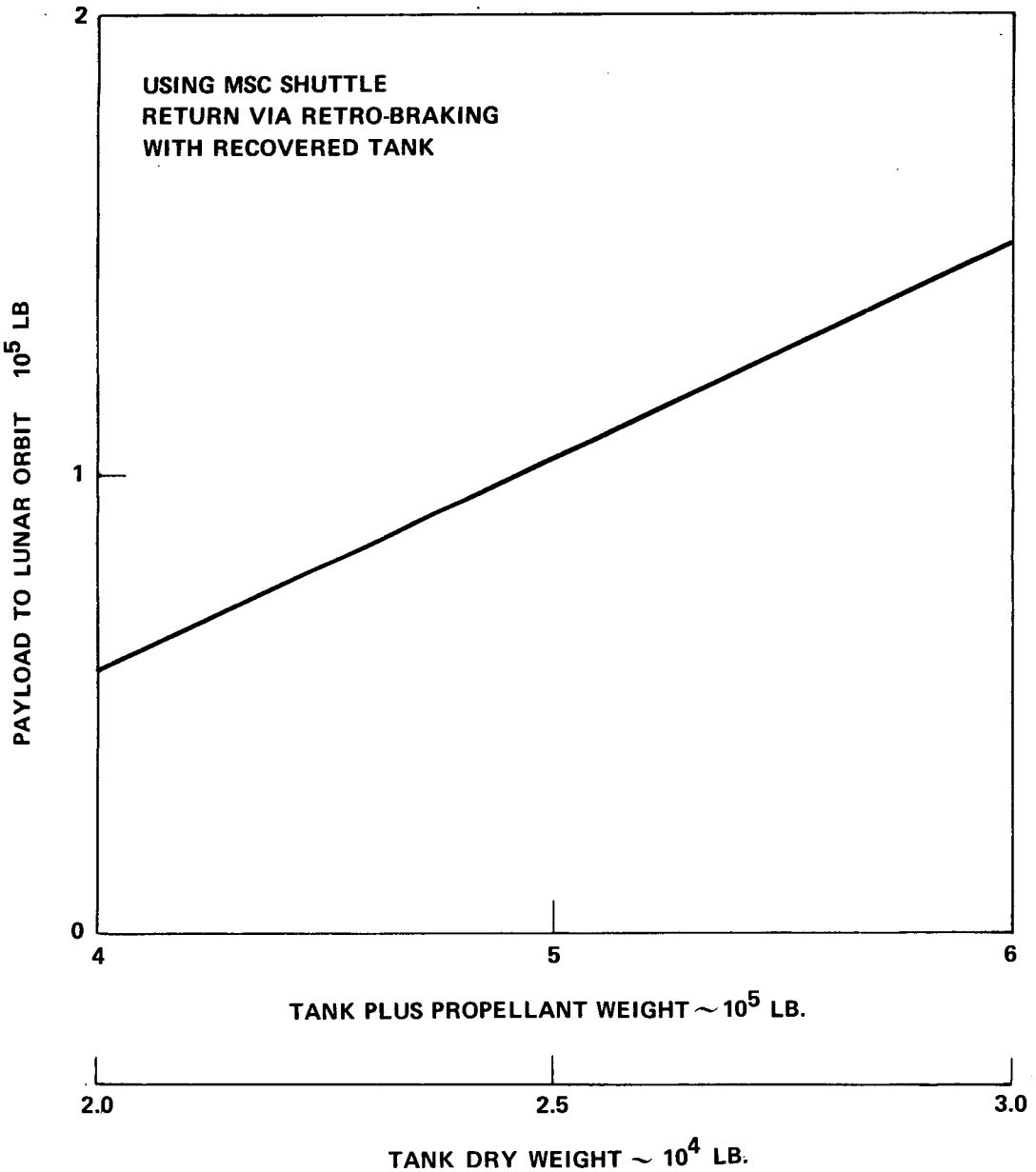

FIGURE 2 - LUNAR PAYLOAD VS TANK SIZE

The number of initial shuttle flights required to earth orbit using the MSC shuttle is summarized below.

Core and tank propellant (1,182,000 lbs.)	- 24 flights
Payload (116,000 lbs.)	- 3 flights
Empty tanks (using shuttle vehicle)	- 2 flights
Total Shuttle Flights	= 29 Flights

This is fewer shuttle flights than that required using the SOH (31 flights are required by the SOH, Reference 1) but considerably more than the 7 shuttle flights required using the nuclear shuttle. The empty tanks would only have to be brought up once; they could be reused after that.

Conclusions

A preliminary analysis shows that a fully reusable space shuttle can fly to low earth orbit carrying an auxiliary propellant tank. After refueling in low earth orbit it is capable of carrying a payload to lunar orbit and returning empty back to earth. As an example configuration, the MSC two stage configuration was analyzed. Results of the analysis show that for a nominal lunar payload (116,000 lbs.) an auxiliary propellant tank is required. The auxiliary tank weight is easily within the shuttle vehicle's 50,000 lbs. payload capacity since it weighs only 26,360 lbs., but is too large to be carried internally in one piece. Therefore it is recommended that the auxiliary tank be divided into two separate tanks and carried up with two shuttle flights. A total of 29 shuttle flights are required to low earth orbit to deliver the empty auxiliary tanks, core vehicle, auxiliary tank propellant, and payload.

Compared to the nuclear shuttle the recurring costs are higher for a fully reusable space shuttle used in lunar missions. But it would make a good temporary substitute.

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Attachments

REFERENCES

1. Eilertson, W. H., "Space Shuttle Replacement for a Cislunar Nuclear Shuttle", Bellcomm Memorandum for File, to be published.

2. NASA Space Shuttle Task Group Report, Volume III, Vehicle Configurations, Prepared by NASA Space Shuttle Task Group, June 12, 1969 (revised).